WATER POLLUTION MONITORING COSTS IN ONTARIO COMPARISON OF ESTIMATED AND ACTUAL COSTS

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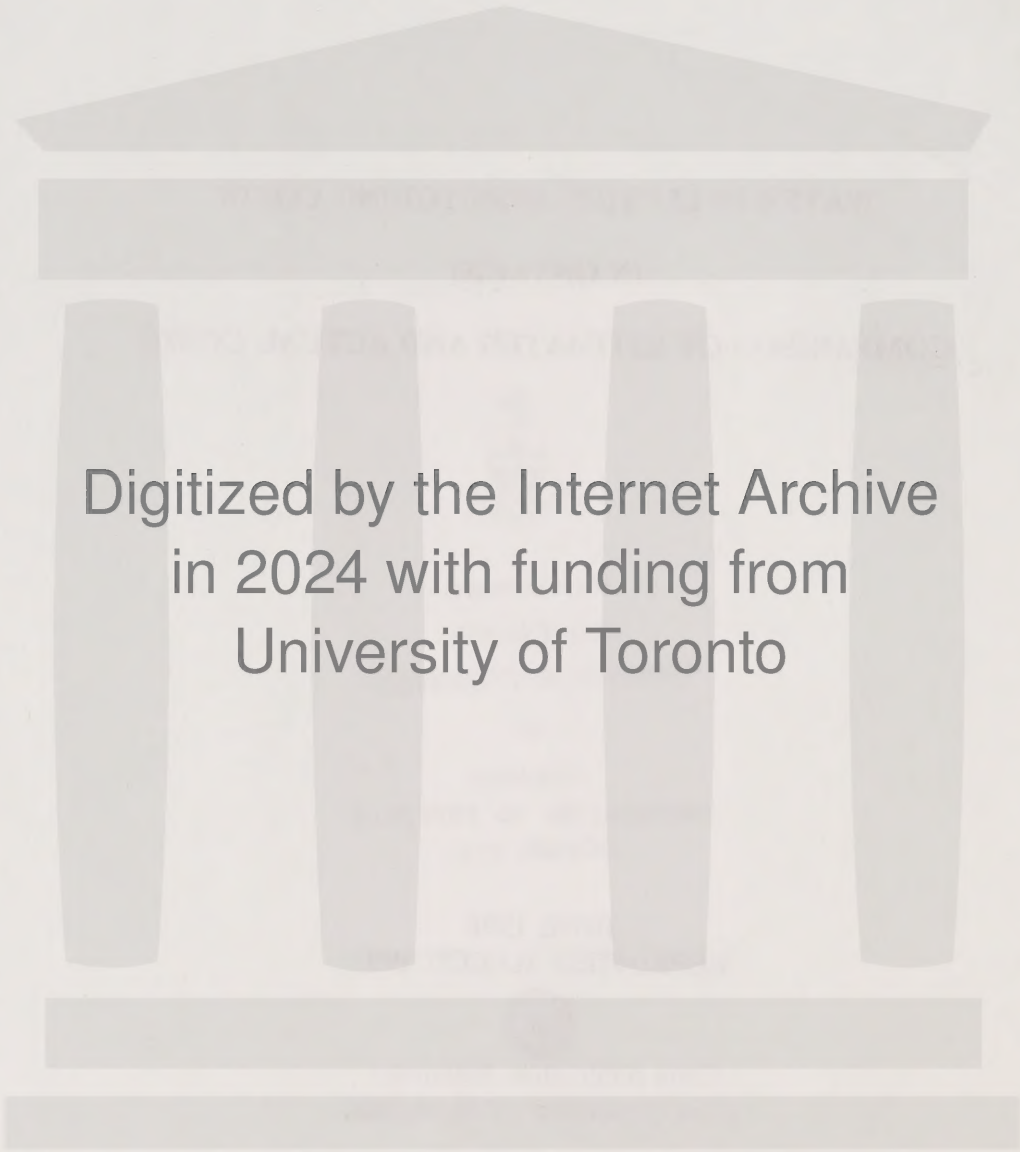

ACKNOWLEDGEMENT

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EXECUTIVE SUMMARY

Purpose of Report

The Municipal-Industrial Strategy for Abatement (MISA) program is intended to achieve the "virtual elimination of toxic contaminants in municipal and industrial discharges into Ontario waterways". As a first step in this program, regulations were promulgated that required intensive 12-month monitoring of industrial wastewater discharges at 237 plants in 9 industrial sectors between December 1, 1988 and July 31, 1991.

Estimates of the capital and operating costs of monitoring activities at each plant were prepared by joint committees of industrial representatives and Ministry staff. Prior to the completion of year-long monitoring programs in each sector, plants were sent questionnaires to obtain data on the actual expenditures incurred for monitoring.

In this report, monitoring activities required by the regulations are described and key results of monitoring efforts are summarized. This is the first time that costs estimates of a monitoring program have been compared with actual reported expenses. Statistical tests were employed to compare reported monitoring costs with the estimated costs used to develop the regulations in order to assess the accuracy of estimated costs.

Key Results of Effluent Monitoring Activities

Different numbers of contaminants or pollution parameters were tested in effluents in each sector. A total of 161 parameters, the largest number of parameters tested for in any of the industrial sectors, were tested for at Metal Casting plants. The largest number of parameters detected in one industrial sector was 116 at the Organic Chemical plants. Effluents from 54% of pulp and paper plants and 42% of organic chemical plants were found to be toxic to fish and other aquatic organisms.

Using monitoring data from plants in each industrial sector, maximum allowable limits were set for specific pollution parameters in each sector ranging from 59 contaminants in the Organic Chemical Sector plants to 1 parameter for Industrial Minerals plants.

Estimated Costs of Monitoring Activities

Estimated monitoring costs totalled $73.7 million for 237 plants, or an average of $311,100 per plant. Operating expenses were estimated to represent 65% of the total expenses. Disaggregated estimates were developed for each monitoring activity: sampling ($25.6 million), flow measurement ($12.9 million), characterization ($11.8 million), routine analysis ($16.2 million),

toxicity testing ($1.6 million), reporting ($5.1 million) and other ($512,300).

The Iron and Steel sector, with 7 plants, was expected to have the highest total estimated costs per plant of $1.2 million, whereas the 51 Industrial Minerals monitoring plants were expected to incur the least total cost of $38,900 per plant. It was estimated that the 7 Iron and Steel plants would incur the highest capital and operating costs per plant; $732,000 per plant and $464,000 per plant respectively.

Reported Costs of Monitoring Activities

Of the 220 plants or mines that were sent a questionnaire requesting data on actual monitoring expenditures, 117 or 53% returned completed questionnaires. These 117 plants reported spending a total of $52.9 million or an average of $452,000 per plant on monitoring activities. The $26.7 million spent on operating expenditures includes $10.2 million to hire external consultants. Total capital and operating cost per plant were $224,000 and $228,000 respectively.

Total expenditures reported for sampling were the highest at $14.2 million or 26.8%, followed by analytical testing ($11.9 million or 22.6%), flow measurement ($10.4 million or 19.7%), reporting ($5 million or 9.5%), training and seminars ($1 million or 2%) and transportation ($109,000 or 0.2%).

The 22 Electric Power plants reported spending the largest total expenditure by sector, $22.5 million, with the lowest total sector expenditure being $43,700 by 2 Metal Casting plants.

External consultants hired generally performed chemical analyses ($6.4 million) and toxicity testing ($1.0 million). The 117 reporting plants established 210 consulting contracts with 55 consulting firms, for an average cost of $42,600 per contract.

Estimated and Reported Costs of MISA Monitoring Activities

Both monitoring cost estimates and reported costs are available for 99 out of 117 plants that returned completed questionnaires. Actual and estimated costs were compared for these plants in order to determine the level of over/under estimation and to determine reasons for such discrepancies for these 99 plants. Total estimated monitoring costs were $7.2 million, or 14% less than total reported costs.

However, total costs were over-estimated by as much as 248% in the Metal Mining Sector, and under-estimated by as much as 43% in the Electric Power Sector.

The range of error within each industrial sector was determined by calculating the ratios of

estimated costs over reported costs by plant within each sector. The range of error was as low as -40% to 19% in the Petroleum Refining Sector to as large as 65% to 1,053% in the Metal Mining Sector.

Standard deviations, calculated to determine the spread in the total sector ratios of estimated to reported costs by plant, show that the spread of ratios for total costs was the least in the Petroleum and Organic Chemical sectors thereby implying that there is more certainty that the estimates represent the actuals.

Two-tailed t-tests were applied to assess whether estimated costs at each plant were within the "confidence limits" of the actual costs. This test indicates that the estimated monitoring costs represent actual monitoring costs within a 95% confidence interval for the same monitoring activities in the Petroleum, Organic, Pulp and Paper and Inorganic Chemical Sectors.

1. INTRODUCTION

1.1 MISA Program: Background

The Municipal-Industrial Strategy for Abatement (MISA) was initiated in 1986 by the Ontario Government. It was intended to reduce or "virtually eliminate" discharges of toxic contaminants into provincial waterways from industrial and municipal effluents. The MISA program consisted of two main stages: effluent monitoring and the development of maximum allowable limits on contaminant loadings in effluents.

Plants in 9 industrial sectors, plus municipal sewage treatment plants, that discharge wastewater directly into provincial waterways, were the focus of this program from its conception.[1]
As of October 1995, the monitoring stage has been completed and the "MISA Clean Water" Regulations, which specify maximum allowable contaminant loadings in effluents, have been promulgated for plants in the 9 industrial sectors.

Effluent monitoring over a 12-month period was required of plants or mines in each industrial sector. The monitoring stage of the MISA program was intended to establish a database of flows, contaminant concentrations and loadings from which contaminants were chosen for regulation and limits were set. These monitoring programs in each industrial sector appear to be the most comprehensive of their kind mandated by any jurisdiction in North America.

Economic assessments were carried out at each stage of the program to help develop monitoring and limits regulations. (MOE, March 1987) The economic analyses consisted of estimates of the magnitude and distribution of the costs of technical options for monitoring or achieving a range of different levels of effluent quantities at each plant. (Salamon and Donnan, 1988)

During the development of regulations which would mandate rigorous year-long effluent monitoring programs at eligible plants in the nine designated industries, Ministry staff and industrial representatives prepared estimates of the costs of the monitoring regimes prescribed for each sector. Assessments of the financial effects which the estimated monitoring costs might have on the regulated firms were completed and reported for each industrial sector.

After the monitoring programs were completed, Ministry of Environment staff sent a questionnaire to each regulated plant to determine how much was actually spent on the various

[1] (1) Petroleum Refining, (2) Organic Chemicals, (3) Inorganic Chemicals, (4) Pulp and Paper, (5) Mining, (6) Iron and Steel, (7) Industrial Minerals, (8) Metal Casting and (9) Electric Power.

monitoring activities mandated by the Regulations. In addition, the questionnaire survey requested data on:

1. The number of additional employees hired to perform MISA monitoring activities;

2. Any beneficial consequences for the regulated plants that might result from the monitoring program; and

3. The operation of the plants, current employment, major products, and production capacity.

Responses to the survey were used to:

1. Document the actual costs of this extensive water pollution monitoring program.

2. Compare reported expenses with cost estimates that were made prior to the monitoring program implementation in order to evaluate the accuracy of the estimation procedures.

1.2 Purpose of the Report

The intent of this report is to:

- Delineate the monitoring activities required by the monitoring regulations and summarize some of the key results of these activities;

- Summarize the estimated capital, operating and total incremental monitoring costs that were estimated by MOEE prior to implementing the monitoring program for each of the industrial sectors.

- Summarize the reported capital, operating and total costs incurred by monitoring plants/mines that were obtained from the survey;

- Compare the reported monitoring costs with the estimated costs used to develop the regulations and assess their accuracy.

The economic and financial effects of the estimated or reported monitoring costs are not assessed in this report but such analyses can be found in reports on individual sectors (MOE July 1988, MOE February 1989, MOE June 1989, MOE August 1989, MOE May 1989, MOE December 1989 (2 reports), MOE September 1989, MOE August 1990).

2. MISA MONITORING PROGRAM

2.1 Effluent Monitoring Activities

The MISA Effluent Monitoring Regulations required direct dischargers to monitor and report to the MOEE wastewater flows, concentrations and total loadings of contaminants present in their wastewater effluents.

Five major monitoring activities were specified by the General Effluent Monitoring Regulation (MOE, 1988), to which all dischargers were subject:

1. Sampling (sites and frequencies), the collection and transportation of samples to labs.
2. Flow Measurement
3. Chemical Analyses ("characterization"[2] and routine analyses)
4. Bio-toxicity testing
5. Data Storage and Reporting

In addition, the General Effluent Regulation specified sampling, analytical, quality assurance and quality control (QA/QC), and reporting procedures and protocols which had to be followed by all plants subject to the monitoring regulations.

Up to 13 different types of effluent streams or "sampling points" were monitored in each sector:

1. Process effluents
2. Once-through cooling water effluents
3. Waste disposal site effluents (leachate)
4. Emergency overflow effluents
5. Backwash effluents
6 Storm water run-off effluents
7. Combined process effluents
8. Batch discharge
9. Boiler blowdown
10. Event Discharge
11. Emergency Overflow
12. Final Discharge
13. Equipment cleaning

[2] Characterization is the analysis of a sample to identify and quantify all of the parameters.

Because of the differences in the types of pollutants generated, the nature of production processes and other considerations, MISA monitoring requirements varied from sector to sector. For example, 7 petroleum refineries were required to test for the same compounds at similar frequencies. Alternatively, plant-specific lists of contaminants and sampling frequencies were developed for each organic and inorganic chemical plant. Pulp and paper mills with the same manufacturing or pulping processes were subject to the same monitoring protocols but monitoring requirements differed from one process subsector to another.

After much negotiation between government and representatives of the regulated industries, it was decided **not** to require monitoring of intake water at plants which obtain process water directly from a lake or river. Therefore, data to determine plant effluent loadings net of loadings in intake waters were not collected by all plants.

Industrial plants in each sector were monitored for 12 months as shown in Table 1. The first Monitoring Regulation began on December 1, 1988 (Petroleum Refining) and the last one finished on July 31, 1991 (Industrial Minerals Sector).

TABLE 1

PERIODS OF MISA EFFLUENT MONITORING BY SECTOR

SECTOR	MONITORING PERIOD	NUMBER OF MONITORING PLANTS
Petroleum	Dec. 1, 1988 - Nov. 30, 1989	7
Organic Chemicals	Oct. 1, 1989 - Sept 30, 1990	26
Inorganic Chemicals	Dec. 1, 1989 - Nov. 30, 1990	29
Iron and Steel	Nov. 1, 1989 - Oct. 31, 1990	7
Pulp and Paper	Jan. 1, 1990 - Dec. 31, 1990	27
Metal Casting	May 1, 1990 - April 30,1991	8
Metal Mining	Feb. 1, 1990 - Jan. 31, 1991	47
Electric Power	June 1, 1990 - May 31, 1991	22
Industrial Minerals Salt Plants Other	 Feb. 1, 1990 - Jan. 31, 1991 Aug. 1, 1990 - July 31, 1991	47
TOTAL:	**Dec 1, 1988 - July 31, 1991**	**222**

2.2 Types of Contaminants Monitored

Contaminants monitored were characterized as "conventional" (eg. total suspended solids (TSS), total organic carbon (TOC), biological oxygen demand (BOD)), "non-conventional" (eg. non-

persistent toxic pollutants such as cyanide, phenols, ammonium ammonia) and "toxic" including metals (eg. iron, mercury, cadmium) and synthetic organic chemicals (eg. dioxins and furans). Development of these definitions and determination of contaminants to be regulated were aided by two documents, The Effluent Monitoring Priority Pollutant List, (EMPPL), 1988 and an update released in 1989, which listed over one hundred contaminants and documented their acute and chronic toxicity, their environmental persistence and their bio-accumulative tendencies.

Once assembled, effluent monitoring data were used to:

- Identify and quantify the loadings (mass per unit time) of all contaminants in order to establish a comprehensive database for direct discharges in Ontario;
- Select parameters for technology-based effluent limits during the MISA limits setting stage of the program;
- Help generate the contaminant reduction components of abatement cost functions for each plant; and
- Calculate maximum allowable loading or concentration limits for each regulated plant.

2.3 Results of Monitoring Activities

The number and type of parameters that each plant monitored varied from one industrial sector to another. The largest number of parameters initially **tested for** within one sector was 161 in the Metal Casting Sector, as shown in Table 2.

The number of parameters **detected** as a result of sampling and testing are also listed in Table 2. The largest number of parameters (116) were detected in Organic Chemical sector plant effluents.

In all plants monitored, the largest loadings were detected for 6 "conventional" parameters: Total Suspended Solids, Dissolved Organic Carbon, Volatile Suspended Solids, Total Organic Compounds, Oil and Grease, and Chemical Oxygen Demand. Of the non-persistent toxic contaminants, loadings of Ammonia plus Ammonium were found to be most prevalent in waste waters of Iron and Steel mills, Electric Power generating plants and Inorganic Chemicals plants. Large amounts of nitrates and nitrites were found in the effluents of Iron and Steel and Inorganic Chemicals plants.

The level of toxicity in effluents was measured in terms of short-term (acute) lethality to trout and Daphnia magna (water fleas), two species that represent vertebrate and invertebrate aquatic life. Results of toxicity testing were recorded as: (1) the number of plants that had one or more samples of waste water that are acutely lethal to one or both of the two test species, and (2) the

number of toxic samples out of the total number of samples tested. Acutely lethal effluent is one that kills more than 50% of the test species in an undiluted (100%) sample of the effluent.

TABLE 2

EFFLUENT MONITORING RESULTS BY INDUSTRIAL SECTOR

SECTOR	NUMBER OF PARAMETERS TESTED IN SECTOR PLANTS	NUMBER OF PARAMETERS DETECTED IN ONE OR MORE SECTOR EFFLUENT
PETROLEUM REFINING	149	80
ORGANIC CHEMICALS	155= 14 conventional 141 EMPPL	116
PULP AND PAPER Sulphate (Kraft) Sulphite/Mechanical Corrugating Deinking/Board/Fine papers/Tissue	 135 135 135 135	 77 43 38 49
IRON AND STEEL Integrated Plants Specialty mini-mills	 154 142	 99 42
METAL MINING	150	58
INDUSTRIAL MINERALS	150	34= 9 organic +8 metals +17 conventional
ELECTRIC POWER GENERATION	153	83
INORGANIC CHEMICALS	154 = 138 EMPPL 16 conventional + non-empl	100
METAL CASTING	161	63

EMPPL = Effluent Monitoring Priority Pollutant List.

Source:
Various MISA Development Documents for Effluent Limits Reports and Twelve Month Monitoring Data Reports for the nine industrial sectors.

Among the nine sectors, Pulp and Paper and Organic Chemical plant effluent exhibited the greatest toxicity to aquatic life. Eleven out of 26 Organic chemical plants monitored had effluents that were acutely lethal to both species. Over 65% of the effluent samples tested from Pulp and Paper mills were toxic to Rainbow Trout and 54% of the samples tested were toxic to Daphnia magna. Steel mill effluents were generally non-toxic with 8% of 218 samples tested acutely lethal to Rainbow Trout and only 10% of 217 samples were acutely lethal to Daphnia magna. In a few plants with toxic effluents, it was not known what contaminants caused the toxicity. Consequently, it was not always clear what treatment or pollution prevention technologies should be applied to eliminate toxicity. These plants had to undertake research to find the most effective way of controlling this important pollution parameter.

2.4 Clean Water Limits Regulations

MISA Clean Water Regulations were developed which specify the maximum allowable discharge loadings or concentrations over a specific time period for each regulated plant. Requirements are also specified for quantities of effluent discharged over defined time periods, and for ongoing future monitoring.

Limits on specific parameters from each industrial sector were based on the following (MOE, 1991):

- a statistical analysis of the magnitude and frequency of each contaminant found in effluents.
- the availability of "proven" abatement or pollution prevention technologies.
- the sources of the parameter, and
- the regulation of the parameter on other jurisdictions.

Industry representatives were consulted extensively during this process. As shown in Table 3, limits were set for as many as 59 parameters at Organic Chemical plants while only 1 parameter was regulated at Industrial Minerals plants.[3]

[3] Limits were set for only one parameter in the Industrial Minerals Sector because concentrations of other contaminants were too low to be of concern.

TABLE 3

PARAMETERS FOR WHICH MAXIMUM ALLOWABLE CONCENTRATIONS OR LOADING LIMITS WERE DEVELOPED

SECTOR	NUMBER OF "LIMITED" PARAMETERS	NUMBER OF PLANTS TO COMPLY (as of May 1995)	DATE PROMULGATED	YEAR OF COMPLIANCE FROM DATE OF PROMULGATION OF REGULATION
PETROLEUM REFINING	11	7	Sept 9, 1990	4
ORGANIC CHEMICALS	59	28	Feb 14, 1995	3
PULP AND PAPER(1)	9	26	Nov 25, 1993	3
IRON AND STEEL	12	7	Apr 13, 1995	3
METAL MINING	7	32	Aug 26, 1994	3
INDUSTRIAL MINERALS	1	26	Aug 26, 1994	3
ELECTRIC POWER	9	15	Apr 13, 1995	4
INORGANIC CHEMICALS	40	25	Feb 14, 1995	3
METAL CASTING	13	2	Aug 26, 1994	3

Note:
(1) By year 2002, AOX generated from the bleaching of pulp at the discharger's plant must be eliminated.

Source:
MOE(E), Various reports: September 1992 (2 reports), December 1994, October 1993 (2 reports), September 1993, October 1994, January 1993, and August 1992.

The Ontario Clean Water Regulations also specify that pH be maintained between 6.0 and 9.5, that effluent must not be acutely lethal to rainbow trout or Daphnia magna (water fleas), and that plants must conduct chronic toxicity testing following 12 consecutive months of non-lethal acute lethality test results.

As indicated in Table 3, each plant will have 3 to 4 years after promulgation to comply with the various regulatory requirements.

2.5 Economic Assessment of Limits Setting

Economic Assessments were carried out by MOEE at each stage of the Limits setting process and

the development of Limits Regulations. Abatement cost functions were derived for each plant or mine to show the costs of achieving successively higher degrees of contaminant removal from existing effluent levels and to assess the cost-effectiveness of contaminant removal at each plant and firm.

Cost estimates for specific loading reduction targets derived from the cost functions were then used to evaluate the financial and economic effects on firms and sectors. Implications of incremental abatement costs on company financial indicators, on the capacity of firms to pass on these costs as increased product prices and effects on the competitive position and finance performance of the sector as a whole and its constituent firms were assessed. (See, for example, MOE, August 1992 and MOEE, April 1993).

3. COST ESTIMATES OF MISA MONITORING REQUIREMENTS

3.1 Cost Estimation Procedures

Together with Industry representatives, MOEE staff estimated the incremental costs of MISA monitoring regulations for each regulated plant and analyzed the potential economic and financial implications of these costs on the sector and constituent firms. Reports of these findings were prepared for each of the nine industrial sectors (MOE, July 1988, February 1989, May 1989, June 1989, August 1989, September 1989, December 1989 (2 reports), August 1990).

Capital and operating costs were estimated for each of the five monitoring activities at each plant or mine. Capital costs were one-time expenses for equipment and structures. Capital costs include the installation of automatic sampling and flow measurement devices which can be used in the future. Operating costs are generally expenses that recur from year to year.

Cost estimates were derived by postulating the monitoring activities, equipment, labour requirements, and facilities that would be required at each plant to implement the monitoring protocols specified in the regulations. Estimation errors arose because (1) inputs required for different types of monitoring functions were uncertain, and (2) some flexibility existed as to how individual plants could implement certain monitoring requirements.

All cost estimates are expressed in 1988 dollars and were thought to have a +/- 20% accuracy range.

3.2 Monitoring Cost Estimates by Sector

When the Monitoring Regulations were promulgated, a total of 237 plants were liable to the monitoring requirements. As shown in Table 4, compliance costs were estimated to total $73.7 million, or an average of $311,100 per plant. Table 4 indicates that 65% of the total estimated monitoring expenses ($48.2 million) was allocated to operating, with $25.6 million (35%) being estimated for capital monitoring expenses.

Table 4 shows that the Metal Mining Sector was estimated to incur the largest total cost for all monitoring activities ($18.0 million). The largest capital costs ($6.1 million) were estimated for the Electric Power Sector (Ontario Hydro and Atomic Energy of Canada Limited). The largest operation costs ($14.1 million) were estimated to be incurred by the Metal Mines, which represented 78% of the total costs for that sector.

The Iron and Steel sector, with 7 plants, was estimated to incur the largest average total cost of $1.2 million per plant. The Industrial Minerals sector, with 51 plants, had the smallest average cost of $39,000 per plant.

Both capital and operating costs per plant for monitoring were estimated to be the largest for Iron & Steel mills. Table 4 lists the sectors according to total cost per plant, from the highest to the lowest.

TABLE 4

TOTAL ESTIMATED INCREMENTAL COSTS OF MISA MONITORING REQUIREMENTS

SECTOR	NUMBER OF PLANTS (1)	($'000) CAPITAL	CAPITAL COST/ PLANT	OPERATING	OPERATING COST/ PLANT	TOTAL	TOTAL COST PER PLANT $/PLANT
IRON AND STEEL	7	5,120.9	732	3,250.2	464	8,371.0	1,195.9
ELECTRIC POWER GENERATION	24	6,095.1	254	8,515.1	355	14,610.1	608.8
ORGANIC CHEMICAL	19	2,812.0	148	8,046.5	424	10,858.5	571.5
PETROLEUM REFINING	7	1,575.0	225	2,081.0	297	3,656.0	522.3
PULP AND PAPER	27	3,697.2	137	5,545.0	205	9,242.2	342.3
METAL MINING (2)	67	3,938.0	59	14,067.0	210	18,005.0	268.7
INORGANIC CHEMICAL	22	1,485.7	68	4,106.1	187	5,591.8	254.2
METAL CASTING	13	535.0	41	884.0	68	1,419.0	109.2
INDUSTRIAL MINERALS (3)	51	316.5	6	1,666.5	33	1,983.0	38.9
TOTAL:	**237**	**25,575.3**	108	**48,161.4**	203	**73,736.7**	**311.1**

(1) Number of plants at time of Monitoring Regulation Promulgation.

(2) Assumes that monitoring activities would be carried out by consultants at mining operations.

(3) At the time of regulation development, a total of 114 plants were listed for the Industrial Minerals sector.
However, of the 70 stone, gravel and sand quarries, only 20 were monitored with all 70 quarry operation sharing the costs of monitoring.
Results from the 20 quarries monitored were extrapolated to the rest of the operations.

SOURCE: VARIOUS MISA MONITORING COSTS REPORTS PREPARED BY MOEE.

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3.3 Monitoring Cost Estimates by Activity

Total estimated costs, disaggregated by monitoring activity, are shown in Table 5. The largest proportion of cost (35%) was for the collection and transportation of samples to and from labs. Routine analysis of samples was estimated to account for 22% of the expected total monitoring expenses. Estimated capital expenditures were expected to be the largest for flow measurement activities ($9.9 million). Sampling requirements were estimated to impose the largest operating expenses of $17.0 million.

Appendix A provides a more detailed breakdown of estimated capital and operating costs by monitoring activity for each sector. The Electric Power sector was expected to incur 35% of the total capital costs for sampling. It was estimated that the Iron and Steel Sector would incur about a third of the total capital costs for flow measurement activities. About 85% of the estimated total capital costs for routine analysis was estimated to be incurred by the Metal Mining Sector.

About 55% of the estimated total operating costs for sampling was estimated to be incurred by the Metal Mining Sector. About 50% or $5.1 million in operating costs for characterization was estimated for the Electric Power Sector. About 50% or $5.4 million in total operating costs for routine analysis was estimated for the Organic Chemical sector. Estimated operating costs for toxicity testing were the largest in the Electric Power sector ($472,800).

TABLE 5

ESTIMATED WATER POLLUTION MONITORING COSTS BY ACTIVITY
($'000)

MONITORING ACTIVITY	ESTIMATED CAPITAL	ESTIMATED OPERATING	ESTIMATED TOTAL	% of TOTAL
SAMPLING	8,619.3	17,005.5	25,624.8	35%
FLOW MEASUREMENT	9,976.5	2,968.5	12,945.0	18%
CHARACTERIZATION	1,510.5	10,310.7	11,821.2	16%
ROUTINE ANALYSIS	4,630.0	11,520.3	16,150.3	22%
TOXICITY TESTING	0	1,639.2	1,639.2	2%
REPORTING	839.0	4,232.4	5,071.4	6.9%
MISCELLANEOUS (1)	0	512.3	512.3	0.1%
TOTAL:	25,575.4	48,189.0	73,764.2	100%

NOTE: (1) Includes contingencies and supervision of staff.

SOURCE:
VARIOUS MISA MONITORING COSTS REPORTS PREPARED BY MOE: July 1988, Feb 1989, June 1989, Aug 1989, May 1989, Sept 1989, Dec 1989 (2 reports), and Aug 1990.

3.4 Economic Effects and Implications of Estimated Monitoring Costs

MOEE staff also examined the cost-effectiveness of monitoring requirements. Costs estimates associated with the proposed plant- and stream-specific requirements were compared to the potential estimated costs incurred under a more comprehensive, across-the-board set of requirements. It was concluded that for all sectors, costs under an alternative set of assumptions would imply increased costs for monitoring activities and would process data about effluent quality beyond what is necessary to satisfy the regulations requirements, therefore making the alternative monitoring scenario less cost-effective.

In addition, MOEE staff assessed the financial and economic implications of the estimated monitoring costs on the sectors and firms within each sector. For each regulated plant, selected financial effects of the estimated costs on the consolidated financial performance of the firms were carried out. Effects on individual plants could not be determined because plant-specific financial data were not available. These assessments indicated that the financial effects of monitoring were not likely to be burdensome (Salamon, Donnan, Blyth and Coplan, 1990). This conclusion was supported by the fact that each industrial plant subsequently implemented monitoring programs with little or no protest or delays.

4. SURVEY OF ACTUAL MONITORING COSTS

4.1 Development of the Survey Questionnaire

In 1989, MOEE staff developed a questionnaire to assemble the actual costs, and potential benefits, that industrial plants incurred during the year long monitoring programs. A draft questionnaire was distributed to 27 industrial representatives for comment. The questionnaire was revised in light of their comments. The intent to determine the actual costs of the monitoring requirements was greeted with enthusiasm and support from most of the industry representatives. A copy of the questionnaire is found in Appendix 2.

In June 1990, the Actual Monitoring Cost Questionnaire was distributed to 220 industrial plants which had been subject to the MISA Monitoring Regulations. Questionnaires were not sent to all 237 plants for which costs were originally estimated because some of these plants were closed or had hooked up with municipal sewers and were no longer liable to the MISA Regulations.

The questionnaire was sent out prior to the commencement of the monitoring period for most of the sectors in order to allow plant data collection and recording systems to incorporate the information requirement of the questionnaire.

Along with the completed questionnaire, some respondents provided additional comments and copies of receipts, invoices and other documentation. Follow-up telephone calls were sometimes required to verify and/or clarify initial data on the questionnaire. Questionnaire responses were recorded in a Dbase IV database.

The questionnaire asked for **capital** costs disaggregated into sampling, flow measurement, chemical analyses, toxicity testing and reporting activities conducted in-house. Capital costs were reported as the delivered price of measurement devices, installation costs, construction and building costs, and other one-time equipment purchases and modifications to existing lab facilities.

The questionnaire requested disaggregated **operating** costs into in-house operating expenses for sampling[4], flow measurement[5], reporting[6], analytical testing[7] and training/seminars.

[4] Sampling - operation and maintenance, sample collection, other labour costs, sample containers, and travelling blank and spiked samples.

Operating costs were derived from data on employee classifications, wage/salary rates (including overhead & benefits) and total person hours applied during the year. Training and seminar costs obtained from the survey were based on the number of persons attending, the average time per activity and the wage rate of those attending. The survey also obtained expenditure data on hiring external consultants to carry out a variety of activities including sampling, flow measurement, reporting, chemical analysis, toxicity testing and transportation of sample to and from labs.

4.2 Survey Responses

Of the 220 regulated plants/mines which were sent a questionnaire, 117 plants or 53% returned fully completed questionnaires as shown in Table 6. Only 5 of the 47 plants in the Industrial Minerals sector, 1 of the 7 Iron and Steel mills and 14 out of the 47 mining establishments completed questionnaires. There was 100% participation from the Petroleum Refining Sector and the Electric Power Sector, and high response rates from the Organic Chemicals and Inorganic Chemicals plants.

Of the 103 plants that did not return a questionnaire, 21 plants communicated reasons why they would not participate in the survey. For example, 8 mines reported that they had closed, were not active during the monitoring period, were in receivership, had converted to a closed loop system, or were subject to "severe financial restraints". Of the 8 non-participating Industrial Minerals plants, 6 plants stated they were non-monitoring quarries and therefore, exempt from monitoring requirements. At least two Metal Casting plants had hooked up their discharge systems to municipal sewers and were no longer subject to the monitoring regulations.

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[5] Flow Measurement - calibration, operation and maintenance, other labour cost, sample containers, and travelling blank and spiked samples.

[6] Reporting - data entry, initial report, monitoring analyses report and other.

[7] Analytical testing - chemical analyses, toxicity testing (trout and Daphnia Magna, characterization, and open characterization.

TABLE 6

RESPONSE RATE OF MISA MONITORING COST SURVEY

SECTOR	NUMBER OF MONITORING PLANTS THAT:			
	RECEIVED A QUESTIONNAIRE	FULLY COMPLETED A QUESTIONNAIRE AND RETURNED IT TO MOEE	% OF RESPONSE	RESPONDED BUT DID NOT COMPLETE A QUESTIONNAIRE
PETROLEUM REFINING	7	7	100%	0
ORGANIC CHEMICALS	26	24	92%	0
PULP AND PAPER	27	17	63%	3
IRON AND STEEL	7	1	14%	0
METAL MINING	47	14	30%	8
INDUSTRIAL MINERALS	47	5	10%	8
ELECTRIC POWER GENERATION	22	22	100%	0
INORGANIC CHEMICALS	29	25	86%	0
METAL CASTING	8	2	25%	2
TOTAL:	**220**	**117**	**53%**	**21**

Source:
MOE, Actual Cost of Monitoring Survey, 1991.

5. SURVEY RESULTS - REPORTED MONITORING COSTS

5.1 Actual Monitoring Costs by Sector

As shown in Table 7, 117 regulated plants reported spending a total of $52.9 million, or an average of $452,000 per plant, on regulated MISA monitoring activities. This cost per plant is 45% higher than the estimated costs of $311,000 per plant. Reported capital and operating costs were split 50-50; $26.2 million for capital and $26.7 million for operating costs. An average of $224,000 per plant for capital expenditures and $228,000 per plant for operating costs was reported.

The survey revealed that 22 electric power generating stations reported the largest capital ($13.5 million) and operating ($8.9 million) expenses of all sectors totalling $22.4 million.

As shown in Table 7, the largest total monitoring cost per plant of $1.7 million was reported by the single Iron and Steel plant that responded to the survey. Electric Power plants spent about $1 million per plant. Metal Casting foundries reported the smallest average cost per plant; $21,900 per plant. Per plant, capital cost and operating cost were the largest in the one Iron and Steel plant where $699,300 was spent on capital and $1 million spent on operating costs.

Of the total reported $52.9 million spent on monitoring activities summarized in Table 8, $42.7 million was spent on in-house monitoring activities and $10.2 million was spent to hire external consultants. Table 8 also shows that the largest percentage of total reported cost (27%) or $14.2 million was spent to collect samples for analysis.

More details of reported capital and operating costs by monitoring activity for each sector are presented in Appendix 3. Capital expenditures for sampling facilities represented 64% of the total costs for sampling activities. Capital expenditures for flow measurement represented most (91%) of the reported costs for this activity. Reported capital and operating costs were more equally distributed for analytical testing activities ie. 55% for capital and 44% for operating costs. Most of the costs for reporting (81%) were operating expenses.

TABLE 7

TOTAL REPORTED CAPITAL AND OPERATING COSTS OF MISA MONITORING BY SECTOR

SECTOR	NUMBER OF PLANTS	($'000)					
		CAPITAL (1)	CAPITAL COST/ PLANT	OPERATING (2)	OPERATING COST/ PLANT	TOTAL	TOTAL COST PER PLANT
IRON AND STEEL	1	699.3	699.3	1,007.2	1,007.2	1,706.5	1,706.5
ELECTRIC POWER GENERATION	22	13,554.9	616.1	8,916.0	405.3	22,470.9	1,021.4
PETROLEUM REFINING	7	1,835.8	262.3	2,236.5	319.5	4,072.3	581.8
ORGANIC CHEMICAL	24	5,382.8	224.3	7,253.6	302.2	12,636.4	526.5
PULP AND PAPER	17	2,470.4	145.3	2,691.8	158.3	5,162.2	303.7
INORGANIC CHEMICAL	25	1,795.6	71.8	2,890.7	115.6	4,686.3	187.5
METAL MINING	14	357.8	25.6	1,423.9	101.7	1,781.7	127.3
INDUSTRIAL MINERALS	5	105.2	21.0	279.5	55.9	384.7	76.9
METAL CASTING	2	5.2	2.6	38.5	19.3	43.7	21.9
TOTAL:	**117**	**26,207.0**	224.0	**26,737.7**	228.5	**52,944.7**	**452.5**

NOTE:
(1) Actual capital costs include purchased vehicles.
(2) Actual operating costs include consultant and vehicle leased costs.

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TABLE 8

REPORTED COSTS BY MONITORING ACTIVITY

MONITORING ACTIVITY	CAPITAL ($'000)	OPERATING ($'000)	TOTAL ($'000)	% OF TOTAL
SAMPLING	9,072.2	5,098.0	14,170.1	27%
ANALYTICAL TESTING	6,612.3	5,343.8	11,956.1	23%
FLOW MEASUREMENT	9,574.0	858.1	10,432.2	20%
CONSULTANTS HIRED	n/a	10,225.2	10,225.2	19%
REPORTING	939.2	4,068.4	5,007.7	9%
TRAINING/ SEMINARS	n/a	1,044.3	1,044.3	1.9%
TRANSPORTATION	n/a	109.1	109.1	0.1%
TOTAL	**26,197.7**	**26,746.9**	**52,944.7**	100%

Note: Totals may differ due to rounding.

n/a = not applicable.

Source: MOEE, Actual Cost of Monitoring Survey, 1991.

The monitoring program was worth at least $10.2 million to consultants. This expenditure amounted to 19% of the total actual costs as shown in Table 8. The types of monitoring activities performed by consultants included sampling, flow measurement, reporting, chemical analyses, toxicity testing and transportation of samples to and from labs. In some cases, the same consultant was hired by more than one plant within the same sector.

Table 9 shows that a total of 240 consulting contracts were set up with 55 consulting firms to perform MISA monitoring activities. The Pulp and Paper sector hired the largest number of consultants (20) followed by the Organic Chemical sector (19), the Inorganic Chemical sectors (17) and Metal Casting sector (17).

The Organic Chemical sector spent the most money ($2.9 million) on consultants, followed closely by the Electric Power Sector ($2.4 million). One Iron and Steel plant spent the largest amount per plant ($456,000) to hire 4 consultants. The one reporting plant in the Iron and Steel Sector also spent the largest amount ($114,000) for the average consultant cost per contract.

Most of the money spent to hire consultants (62% or $6.4 million of the total reported consultant costs) was for chemical analyses as shown in Table 10. About $1 million was spent to hire consultants to perform toxicity testing.

TABLE 9

TOTAL REPORTED CONSULTANT EXPENDITURES BY INDUSTRIAL SECTOR

MISA SECTOR	NUMBER OF PLANTS THAT COMPLETED A QUESTIONNAIRE	NUMBER OF CONSULTANTS HIRED	NUMBER OF CONSULTANT CONTRACTS REPORTED	TOTAL CONSULTANT COSTS ($'000)	TOTAL CONSULTANT COST PER PLANT ($'000)	TOTAL CONSULTANT COST PER CONTRACT ($'000)
PETROLEUM SECTOR	7	11	23	676.7	96.7	29.4
ORGANIC CHEMICALS	24	19	50	2,912.6	121.4	58.3
PULP AND PAPER	17	20	45	1,378.1	81.1	30.6
IRON AND STEEL	1	4	4	456.0	456.0	114.0
METAL MINING	14	17	29	787.1	41.4	27.1
INDUSTRIAL MINERALS	5	7	10	184.7	36.9	18.5
ELECTRIC POWER GENERATION	22	10	31	2,410.9	109.6	77.7
INORGANIC CHEMICALS	25	17	46	1,403.2	56.1	30.5
METAL CASTING	2	2	2	16.0	8.0	8.0
TOTAL	117	n/a *	240	10,225.2	87.4	42.6

n/a = not applicable.

* There were a total of 55 different consulting firms hired to perform monitoring activities.

SOURCE: MOEE, ACTUAL COST OF MONITORING QUESTIONNAIRE, 1991.

TABLE 10

CONSULTANT COSTS BY SECTOR BY MONITORING ACTIVITY

SECTOR	SAMPLING ($)	FLOW MEASUREMENT ($)	REPORTING ($)	CHEMICAL ANALYSES ($)	TOXICITY TESTING ($)	TRANSPORTATION CHEMICAL ANALYSES ($)	TRANSPORTATION TOXICITY TESTING ($)	TOTAL * ($)	TOTAL COST * ($)
PETROLEUM REFINING	20,000	3,789	70,021	276,671	54,800	2,708	2,454	5,162	**676,723**
ORGANIC CHEMICALS	170,900	4,000	203,848	1,896,263	207,357	61,491	4,673	90,228	**2,912,635**
PULP AND PAPER	0	121,380	1,000	1,069,191	95,700	20,547	14,466	56,652	**1,378,095**
IRON AND STEEL	0	20,000	260,000	152,000	24,000	0	0	0	**456,000**
METAL MINING	1,300	122,569	35,800	564,865	32,420	25,212	4,920	30,132	**787,086**
INDUSTRIAL MINERALS	17,000	12,000	15,000	64,000	10,000	1,343	1,243	2,586	**184,662**
ELECTRIC POWER	41,000	2,000	0	1,526,008	478,630	29,209	0	91,731	**2,410,897**
INORGANIC CHEMICALS	43,030	66,884	54,195	831,982	94,577	10,234	9,140	34,027	**1,403,243**
METAL CASTING	900	0	0	13,896	1,000	90	90	180	**15,976**
TOTAL (117 PLANTS):	**294,130**	**352,622**	**639,864**	**6,394,876**	**998,484**	**150,834**	**36,986**	**310,698**	**10,225,317**
% of TOTAL:	3%	3%	6%	63%	10%	1%	0%	3%	100%

* Note: Columns may not add up to total columns due to lack of information provided on questionnaire.

SOURCE: MOEE, ACTUAL COST OF MONITORING QUESTIONNAIRE, 1991.

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6. REPORTED VERSUS ESTIMATED COSTS OF MISA MONITORING

6.1 Method of Cost Comparison

The total estimated costs as shown in Table 4 cannot be directly compared with total reported costs as shown in Table 7, because estimates were prepared for a different number and set of plants than those which reported costs to the survey.

The plants that were initially identified in the MISA Monitoring Regulations, and for which costs were estimated, changed over time because:

- Some plants hooked up to municipal sewage systems or converted their processes to a closed loop system. Consequently, these plants were no longer liable to any MISA Regulations.

- Some plants or mines closed while others were opened.

- New plants were added to the list of regulated plants required to do monitoring.

- Some mines were not operating at the time monitoring was required.

Of the 237 plants for which monitoring costs were estimated and the 117 plants for which actual monitoring costs were obtained from the survey, a total of 99 plants have both estimated and actual costs for monitoring activities.

6.2 Comparison of Reported and Estimated MISA Monitoring Costs

For the 99 plants whose estimated and actual costs can be compared, total estimated costs ($43.6 million) were $7.2 million or 14% lower than reported costs ($50.9 million) as shown in Table 11. Total estimated capital costs ($16.4 million) are $9.1 million or 36% lower than the actual capital costs ($25.5 million) for these 99 plants. Total estimated operating costs ($27.2 million) are $2.0 million or 7% lower than the reported operating costs ($25.4 million).

All sectors, except the Metal Mining sector and the 1 Iron & Steel plant, have estimated **capital** costs lower than the reported actuals. The largest difference in the estimated versus the reported **capital** costs is in the Metal Mining sector, where estimated capital costs are 497% larger than the reported costs. Capital costs for the 1 Iron and Steel plant were overestimated by 183%

In the Electric Power sector, which consists of 20 Ontario Hydro plants plus 2 Atomic Energy

of Canada facilities, **capital** costs were underestimated by 61%. In comparing estimated versus reported capital costs by monitoring activity for Ontario Hydro plants only, the greatest differences in these costs were in the in-house sampling ($2.4 million), in-house flow-measurement ($3.1 million), and in-house analytical testing ($2.3 million) activities. This large underestimation of capital costs by Ontario Hydro was a result of changes to the MISA monitoring requirements after monitoring cost estimates were prepared by Ontario Hydro.

Capital cost estimates in the Organic Chemical Sector where also significantly lower (59%) than the reported costs. Most (97%) of the $2.9 million difference in capital costs was in sampling and chemical analysis activities. Therefore, the prices and number of devices required such as automatic samplers, storage, sampler refrigerators, and routine analysis equipment were likely underestimated. In addition, capital cost estimates are especially prone to uncertainties about installation of instrumentation and the construction of facilities which are often very complex and therefore more costly than had been estimated.

Estimated **operating** costs were lower than those reported for the Petroleum, Organic Chemicals, Electric Power, and Metal Casting sector, and 1 Iron and Steel plant. Overestimation of operating costs were the largest in the Metal Mining sector, where estimated costs were 185% larger than reported actuals. Most (74%) of this difference in the estimated versus the actual operating cost was due to the overestimation of costs to hire external consultants.

The U.S. Environmental Protection Agency assessed the accuracy of estimated costs of complying with federal environmental laws by use of a ratio analysis of estimated over actual costs (Putnam, Hayes & Barlett, 1980). The ratios of estimated-to-actual expenditures for monitoring activities by plant were calculated to determine the range of error as shown in Table 12. The Iron and Steel, Metal Casting and the Industrial Minerals sector has been left out because the number of plants is less than or equal to 3, and therefore do not constitute a sufficient sample size.

Standard deviations can also be used to predict the future or be used for forecasting. Table 12 also shows the standard deviations of the estimated-to-actual plant ratios. Standard deviations of total costs for the Petroleum and Organic Chemical sectors are the closer to zero suggesting a smaller spread in the ratios from their mean, therefore indicating a better accuracy of estimates.

TABLE 11

REPORTED VERSUS ESTIMATED TOTAL MONITORING COSTS BY SECTOR

SECTOR	NUMBER OF PLANTS (for which both estimated and reported costs are available)	ESTIMATED CAPITAL COSTS ($'000)	REPORTED CAPITAL COSTS * ($'000)	CAPITAL COSTS % DIFFERENCE (EST–REP/REP)	ESTIMATED OPERATING COSTS ($'000)	REPORTED OPERATING COSTS ** ($'000)	OPERATING COSTS % DIFFERENCE (EST–REP/REP)	ESTIMATED TOTAL COSTS ($'000)	REPORTED TOTAL COSTS ($'000)	TOTAL COSTS % DIFFERENCE (EST–REP/REP)
PETROLEUM REFINING	7	1,575.0	1,835.8	–14%	2,081.0	2,236.5	–7%	3,656.0	4,072.3	–10%
ORGANIC CHEMICALS	14	2,024.0	4,900.9	–59%	5,335.3	6,325.9	–16%	7,359.3	11,226.8	–34%
PULP AND PAPER	17	2,189.2	2,470.4	–11%	3,545.4	2,691.8	32%	5,734.6	5,162.2	11%
IRON AND STEEL	1	1,981.9	699.3	183%	851.0	1,007.2	–16%	2,832.9	1,706.5	66%
METAL MINING	14	2,134.7	357.8	497%	4,060.4	1,423.9	185%	6,195.1	1,781.7	248%
INDUSTRIAL MINERALS	3	14.5	15.5	–6%	133.1	115.9	15%	147.6	131.4	12%
ELECTRIC POWER GENERATION	22	5,274.7	13,554.9	–61%	7,558.2	8,916.0	–15%	12,832.9	22,470.9	–43%
INORGANIC CHEMICALS	19	1,189.2	1,704.7	–30%	3,636.5	2,614.3	39%	4,825.7	4,319.0	12%
METAL CASTINGS	2	3.3	5.2	–37%	30.2	38.5	–22%	33.5	43.7	–23%
TOTAL	99	16,386.5	25,544.5	–36%	27,231.1	25,370.0	7%	43,617.6	50,914.5	–14%

NOTE:
*Actual capital costs include purchased vehicle costs.
** Actual operating costs include consultant and vehicle leased costs.

SOURCE:
ESTIMATED COSTS – VARIOUS MISA ESTIMATED MONITORING COST REPORTS PREPARED BY MOEE.
REPORTED COSTS – MOE, ACTUAL COST OF MONITORING SURVEY, 1991.

TABLE 12

RATIO OF ESTIMATED AND REPORTED MONITORING EXPENDITURES WITHIN EACH SECTOR

SECTOR	NUMBER OF PLANTS	CAPITAL COSTS			OPERATING COSTS			TOTAL COSTS		
		RANGE BY PLANT	MEAN	STANDARD DEVIATION	RANGE BY PLANT	MEAN	STANDARD DEVIATION	RANGE BY PLANT	MEAN	STANDARD DEVIATION
PETROLEUM REFINING	7	0.38 to 1.33	0.88	0.37	0.78 to 1.13	0.95	0.13	0.60 to 1.19	0.90	0.16
PULP & PAPER	17	0.02 to 4.66	1.11	1.31	0.67 to 2.72	1.44	0.53	0.79 to 2.53	1.31	0.53
ORGANIC CHEMICALS	14	0 to 1.36	0.43	0.37	0.37 to 2.15	1.01	0.42	0.39 to 1.30	0.78	0.29
INORGANIC (1) CHEMICALS	17	0 to 3.01	0.60	0.68	0.52 to 2.23	1.38	0.57	0.44 to 2.14	1.11	0.49
ELECTRIC POWER	22	0 to 3.46	0.76	0.79	0.32 to 3.41	1.28	0.86	0.25 to 2.65	0.96	0.69
METAL MINING	14	0 to 450	40.23	118.55	2 to 10.37	4.94	2.65	1.65 to 11.53	4.99	2.93
TOTAL (2)	91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE:

(1) THE VALUE OF 2 PLANTS WHICH WE SUSPECT THEIR ACCURACY HAVE BEEN LEFT OUT SINCE THEY BIASES OUT ESTIMATES.

(2) ESTIMATED AND REPORTED MONITORING COSTS ARE AVAILBLE FOR 3 OR LESS PLANTS WITHIN THE INDUSTRIAL MINERALS, METAL CASTING AND IRON AND STEEL SECTOR. THEREFORE, SINCE THE NUMBER OF PLANTS IS NOT A SUFFICIENT SAMPLE SIZE THESE SECTORS HAVE NOT BEEN INCLUDED IN THIS TABLE.

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6.3 Statistical Tests

6.3.1 Monitoring Costs By Plant

Estimated and reported monitoring costs by plant were analyzed with a two-tailed "t-test" to determine the level of confidence by which monitoring cost estimates represented the actual costs of monitoring activities. Refer to Appendix 4.

The two-tailed "t-test" was applied to data from 6 of the 9 sectors. The Iron and Steel, Industrial Minerals and Metal Casting sector consisted of only 1 to 3 plants, too few for this analysis. A two-tailed "t-test" was applied to assess whether a sample of observation is, in fact, part of a known population. In this study, the known population is the reported monitoring costs.

The calculated "t test statistic" for the Petroleum, Organic, Pulp and Paper, and Inorganic sectors, fell into the critical range for the 5% level of significance. Therefore, it can be concluded that estimates for these 4 sectors have a 95% chance of representing the actual costs of monitoring activities. The "t-test" statistics calculated for the Electric Power sector and the Metal Mining are greater than the upper limit for the 95% confidence interval and therefore, it can be concluded that the estimates for these sectors do not statistically represent the actual costs of monitoring in those plants.

6.3.2 Total Monitoring Costs By Sector

For the 99 plants which have both estimated and actual costs, the total estimated and reported costs by sector were compared using a two-tailed "t-test" to determine the level of confidence that MOEE has in using their estimates to represent the actual costs of monitoring. Refer to Appendix 5.

The same procedure was used as described in section 6.3.1 above except that the total cost by sector is considered to be an observation, with the total number of observations equal to the number of sectors, which is 9 in this case.

With a 5% level of significance and 2(n-1)=16 degree of freedom, the calculated "t-test statistic" was less than the critical "t-value". It can be concluded that overall, the estimated cost by sector represent the reported costs by sector of MISA monitoring activities with a 95% level of certainty.

7. EMPLOYMENT AND OTHER CONSEQUENCES OF MISA MONITORING REQUIREMENTS

7.1 Employment Associated with Monitoring Requirements

The 117 survey respondents reported that a total of 106 persons were hired to perform **in-house** MISA monitoring activities, as shown in Table 13. Of these 106, 62 were hired on a permanent basis whereas 44 were temporarily hired for one year. Organic Chemical plants hired 39 persons, the largest number of additional employees, consisting of 23 permanent and 16 temporary persons. The Electric Power Sector hired 29 (18 permanent and 11 temporary positions). All sectors except the Industrial Minerals and Metal Casting Sectors reported to have hired at least 3 persons.

TABLE 13

REPORTED NUMBER OF ADDITIONAL EMPLOYEES HIRED IN-HOUSE TO PERFORM MISA MONITORING ACTIVITIES

MISA SECTOR	PERMANENT		TEMPORARY		TOTAL
	FULL-TIME	PART-TIME	FULL-TIME	PART-TIME	
PETROLEUM REFINING	4	0	2	1	7
ORGANIC CHEMICALS	21	2	12	4	39
PULP & PAPER	8	1	3	1	13
IRON AND STEEL	1	0	2	0	3
METAL MINING	0	1	5	0	6
INDUSTRIAL MINERALS	0	0	0	0	0
ELECTRIC POWER	15	3	4	7	29
INORGANIC CHEMICALS	6	0	1	2	8
METAL CASTING	0	0	0	0	0
TOTAL	**55**	**7**	**29**	**15**	**106**

SOURCE: MOEE, Actual Cost Of Monitoring Survey, 1991.

7.2 Person Hours Worked for MISA Monitoring Activities

The 117 survey respondents reported a total of 343,416 person hours to perform **in-house** monitoring activities. This figure does not include time for training, seminars or the person hours of hired consultants. As shown in Table 14, for all sectors, analytical testing consumed the largest number of labour hours conducted in-house (127,135 hours) followed closely by sampling (114,469 hours). Of the total 343,416 in-house person hours reported, 37% was for analytical testing, 33% was for sampling, 24% was for reporting, and 6% was for flow measurement.

Survey results show that the number of person hours for one year of in-house MISA monitoring was the greatest in the Electric Power sector (108,693 hours) followed by the Organic Chemical sector (89,355 hours).

In-house person hours per plant was the largest for the one reported Iron and Steel plant ie. 14,978 hours. As indicated previously, this plant also incurred the largest cost per plant to hire external consultants. This may suggest that monitoring activities in the Iron and Steel sector are more complex and intense.

Based on the total of 117 reported plants, reported operating costs per total person in-house hours by sector ranged from $63.40 per hour in the Petroleum sector to $161.80 per hour in the Metal Casting sector as shown in Table 15.

TABLE 14

TOTAL NUMBER OF PERSON HOURS PER YEAR TO PERFORM MONITORING ACTIVITIES CONDUCTED IN-HOUSE

MISA SECTOR	NUMBER OF PLANTS (1)	PERSON HOURS (IN-HOUSE)				TOTAL PERSON HOURS	PERSON HOURS PER PLANT
		SAMPLING	FLOW MEASUREMENT	REPORTING	ANALYTICAL TESTING		
PETROLEUM REFINING	7	8,621	504	9,337	16,820	35,282	5,040
ORGANIC CHEMICALS	24	40,016	3,405	21,310	24,624	89,355	3,723
PULP AND PAPER	17	13,811	2,055	8,262	12,180	36,308	2,136
IRON AND STEEL	1	3,076	2,748	4,474	4,680	14,978	14,978
METAL MINING	14	5,855	659	6,492	3,854	16,860	1,204
INDUSTRIAL MINERALS	5	1,429	309	399	780	2,917	583
ELECTRIC POWER GENERATION	22	28,633	8,967	23,285	47,808	108,693	4,941
INORGANIC CHEMICALS	25	12,968	2,017	7,411	16,389	38,785	1,551
METAL CASTING	2	60	50	128	0	238	119
TOTAL	**117**	**114,469**	**20,714**	**81,098**	**127,135**	**343,416**	n/a
% OF TOTAL	n/a	33.33%	6.03%	23.62%	37.02%	100.00%	n/a

(1) Based on the total number of plants that completed a questionnaire.
n/a = not applicable.

SOURCE: MOEE, ACTUAL COST OF MONITORING SURVEY, 1991.

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TABLE 15

MONITORING PERSON HOURS AS A % OF REPORTED MONITORING COSTS

MISA SECTOR	NUMBER OF PLANTS	REPORTED OPERATING MONITORING COST ($'000)	IN-HOUSE PERSON HOURS	OPERATING COSTS PER TOTAL PERSON HOURS ($/hour)
PETROLEUM REFINING	7	2,236.5	35,282	63.4
ORGANIC CHEMICALS	24	7,253.6	89,355	81.2
PULP & PAPER	17	2,691.8	36,308	74.1
IRON AND STEEL	1	1,007.2	14,978	67.2
METAL MINING	14	1,423.9	16,860	84.4
INDUSTRIAL MINERALS	5	279.5	2,917	95.8
ELECTRIC POWER	22	8,916.0	108,693	82.0
INORGANIC CHEMICALS	25	2,890.7	38,785	74.5
METAL CASTING	2	38.5	238	161.8
TOTAL:	117	26,737.7	343,416	n/a

Source: MOE, Actual Cost of Monitoring Survey, 1991.

7.3 Cost Savings Associated with MISA Monitoring Activities

Questions relating to the beneficial consequences of various monitoring activities were asked:

"During and as a result of the monitoring of your effluent, did you find out any of the following about the operation of your company?"

(1) Water use or pumping could be reduced?
(2) Raw materials loss could be reduced?
(3) Product loss or spoilage could be reduced?
(4) Capital equipment acquired for monitoring can be used for other purposes?

Most respondents noted that computer equipment purchased for monitoring could be used for other activities. One plant in the industrial minerals sector indicated that cost saving for capital equipment purchased amounted to $10,000. One plant in the Organic chemical sector reported that the MISA program initiated interest in developing their own laboratory and testing facilities to improve control and response times. The same company stated that the monitoring program enhanced awareness of stream contaminants. The plant reported saving $10,000 from Lab testing, since it was applied to general environmental activities and process studies.

8. SUMMARY AND CONCLUSIONS

Estimated compliance costs for individual sectors and individual plants provide the basis for assessing the cost-effectiveness and the financial and economic implications of proposed regulations or policies prior to their implementation. However, these estimates are seldom verified by comparing them against actual costs incurred.

A survey was completed wherein the actual monitoring costs incurred were obtained from plants subject to the "Ontario Clean Water" monitoring regulations. Costs of different monitoring activities in different industrial sectors were displayed and compared. Estimated monitoring costs prepared prior to the promulgation of the Regulations were compared with the actual expenses in order to validate and improve future cost-estimation procedures.

Monitoring Regulations required 237 plants within nine industrial sectors to monitor their effluents. Up to 161 parameters were tested by plants in each sector. The number of parameters detected in plant effluents ranged from 34 in the Industrial Minerals sector to as high as 116 in the Organic Chemical sector. Effluent monitoring data provided the basis for Effluent Limits Regulations which have been completed for each of the nine sectors and which place maximum allowable limits on from 1 to 59 parameters in plant effluents.

Prior to implementing requirements of the Monitoring Regulations, ministry staff and industry representatives estimated that the total (capital plus operation and maintenance) costs for all sectors would be $73.7 million for 273 plants. The estimated total cost per plant was $311,000.

There were 117 plants which responded to the survey questionnaire and reported actual monitoring expenses averaging $452,500 per plant. Applying the $452,500 per plant figure to 273 plants suggests that industry actually spent as much as (273 x $452,500) $123.5 million to comply with the monitoring regulations. This comparison implies a 40% under-estimation of the total costs of monitoring.

However, of the 117 respondents, only 99 plants also had cost estimates available. From the time that estimates were prepared to promulgation of the monitoring regulations, a number of plants and mines in different sectors were closed or were hooked up to municipal sewers systems (and so were exempt from the monitoring requirements). Moreover, additional plants were found which were liable to the Regulation but had not had cost estimates prepared for them. When comparing these 99 plants, estimated total monitoring costs were only 14% lower, than the total actual costs obtained from the survey. The major discrepancy was with capital costs which were 36% lower than reported costs.

The largest discrepancies between estimated and reported **capital** costs were found in the

following sectors:

- Electric Power - Total capital costs were under-estimated by 61%.
- Organic Chemical - Total capital costs were under-estimated by 59%.
- Metal Mining - Total capital costs were over-estimated by 497%.
- Iron and Steel - Total capital costs were over-estimated by 183%.

According to industry sources, capital costs are often underestimated because installation of instrumentation and construction of facilities were frequently more complex and costly than had been anticipated.

Estimated total operating costs were 7% higher than the survey costs. The largest difference between estimated and actual operating costs was in the Metal Mining sector, where estimated operating costs were 185% higher than the reported operating costs.

Statistical tests show that estimates represent the actual MISA monitoring for the Petroleum, Organic, Pulp and Paper, and Inorganic sectors within a 95% confidence level.

Monitoring requirements generated employment in terms of hiring in-house staff and external consultants to perform monitoring activities. A total of $10.2 billion was spent to hire a total of 55 consulting firms. Industry also hired a total of 62 permanent and 44 temporary staff to perform monitoring activities.

BIBLIOGRAPHY

Ontario Ministry of the Environment (June 1986). **Municipal - Industrial Strategy for Abatement, A Policy and Program Statement of the Government of Ontario on Controlling Municipal and Industrial Discharges into Surface Waters**.

Ontario Ministry of the Environment (March 1987). **Economic Information Needs and Assessments for Developing MISA Monitoring and Abatement Requirements**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (1988). **Effluent Monitoring - General, Ontario Regulation 695/88**.

Ontario Ministry of the Environment, (1988). **The Effluent Monitoring Priority Pollutants List (1987)**.

Ontario Ministry of the Environment (July 1988). **Cost Estimates and Implications of the Effluent Monitoring - General and Effluent Monitoring - Petroleum Refining Sector Regulations for Ontario's Petroleum Refineries**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment, (1989). **The Effluent Monitoring Priority Pollutants Lists, 1988 Update**.

Ontario Ministry of the Environment (February 1989). **Ontario's Organic Chemical Manufacturing Sector, Monitoring Cost Estimates**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (May 1989). **Economic Implications of the MISA Monitoring Regulations on Ontario's Iron and Steel Sector, Final Report**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (June 1989). **Monitoring Costs and their Implications for Direct Dischargers in the Ontario Inorganic Chemical Industry, Final Report**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (August 1989). **Monitoring Costs and their Implications for Direct Dischargers in the Ontario Pulp and Paper Industry, Final Report**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (September 1989). **Monitoring Costs and their Implications for Direct Dischargers in the Ontario Group "A" Sector, Final Report**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (December 1989). **Monitoring Costs and their Implications for Direct Dischargers in the Ontario Metal Casting Industry**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (December 1989). **Monitoring Costs and their Implications for Direct Dischargers in the Electric Generation Sector**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (August 1990). **Monitoring Costs and their Implications for Direct Dischargers in the Ontario Industrial Minerals Sector, Final Report**. Socio-Economic Section, Policy and Planning Branch.

Ontario Ministry of the Environment (1991). **Municipal-Industrial Strategy for Abatement: Issues Resolution Process - Final Report**.

Ontario Ministry of the Environment (September 1991). **MISA Issues Resolution Process, Final Report Summary**.

Ontario Ministry of the Environment (September 1991). **Status Report on the Effluent Monitoring Data For the Iron and Steel Sector.** Water Resources Branch.

Ontario Ministry of the Environment (October 1991). **Draft Protocol For the Sampling and Analysis of Industrial/Municipal Wastewater**.

Ontario Ministry of the Environment (April 1992). **The Metal Mining Sector Effluent Monitoring Data**. Water Resources Branch.

Ontario Ministry of the Environment (August 1992). **Background Document on the Development of the Draft Petroleum Refining Sector Effluents Limits Regulation**. Water Resources Branch.

Ontario Ministry of the Environment (August 1992). **Economic Assessment of Water Pollution Abatement Options For Ontario Petroleum Refineries.** Economic Services Branch.

Ontario Ministry of the Environment (September 1992). **Twelve-Month Monitoring Data Report, Inorganic Chemical Manufacturing Sector**. Water Resources Branch.

Ontario Ministry of the Environment (September 1992). **Twelve-Month Monitoring Data Report, Organic Chemical Manufacturing Sector.** Water Resources Branch.

Ontario Ministry of the Environment (January 1993). **Draft Development Document For the Pulp and Paper Sector Effluent Limits Regulation.** Water Resources Branch.

Ontario Ministry of the Environment and Energy (April 1993). **Economic Assessment of Water Pollution Abatement Options For Ontario Pulp and Paper Mills.** Economic Services Branch.

Ontario Ministry of the Environment and Energy (September 1993). **Draft Development Document For the Effluent Limits Regulation for the MISA Metal Mining Sector**.

Ontario Ministry of the Environment and Energy (September 1993). **Twelve-Month Monitoring Data Report, Metal Casting Sector**. Water Resources Branch.

Ontario Ministry of the Environment (October 1993). **Draft Development Document For the Effluent Limits Regulation for the Industrial Minerals Sector.** Water Resources Branch.

Ontario Ministry of the Environment and Energy (October 1993). **Draft Development Document For the Effluent Limits Regulation for the MISA Metal Casting Sector**.

Ontario Ministry of the Environment and Energy (September 1994). **Development Document For the Organic Chemical Manufacturing (OCM) Sector, Effluent Limits Regulation**.

Ontario Ministry of the Environment and Energy (September 1994). **Development Document For the Inorganic Chemical Sector, Effluent Limits Regulation**.

Ontario Ministry of the Environment and Energy (October 1994). **Draft Development Document, Clean Water Regulation for the Electric Power Generation Sector, Effluent Monitoring and Effluent Limits**. Industrial Effluent Section, Program Development Branch.

Ontario Ministry of the Environment and Energy (December 1994). **The Draft Development Document For the Effluent Limits Regulation for the MISA Iron and Steel Manufacturing Sector.**

Putman, Hayes & Bartlett, Inc. (June 1980). **Comparisons of Estimated and Actual Pollution Control Capital Expenditures For Selected Industries**. Cambridge, Massachusetts, Washington, D.C..

Salamon, Orna E. and Donnan, Jack A. (November 1988). "Economic Assessments of MISA Regulations for Direct Industrial Dischargers in Ontario", in **Proceedings of 1988 Technology Transfer Conference**, Vol. II, Toronto, Ontario.

Salamon, Orna E., Donnan, Jack A., Blyth, Patricia A., and Coplan, Lee A. (November 1990). "Economic Analyses of Ontario's Water Pollution Control Initiative for Direct Industrial Dischargers", in **Proceedings of 1990 Environmental Resources Technology Transfer Conference**, Vol. II, Toronto, Ontario.

APPENDIX 1

Estimated Capital And Operating Costs By Monitoring Activity For Each Sector

Table 1

Misa Monitoring: Estimated Capital Costs

MISA Sector	Sampling ($)	Flow Measurement ($)	ANALYTICAL TESTING			Reporting ($)	Miscellaneous ($)	Total ($)
			Characterization ($)	Routine Analysis ($)	Toxicity Testing ($)			
Petroleum	506,000	712,000	0	315,000	0	42,000	0	1,575,000
Organic Chemicals	1,391,000	1,016,000	0	257,000	0	148,000	0	2,812,000
Pulp & Paper	817,700	2,798,500	0	0	0	81,000	0	3,697,200
Iron & Steel	1,805,243	3,290,630	0	0	0	25,000	0	5,120,873
Metal Mining	0	0	0	3,938,000	0	0	0	3,938,000
Industrial Minerals	0	10,000	0	0	0	306,500	0	316,500
Electric Power	3,065,550	1,329,000	1,510,518	0	0	190,004	0	6,095,072
Inorganic Chemicals	837,100	498,500	0	120,000	0	30,100	0	1,485,700
Metal Casting	196,750	321,900	0	0	0	16,425	0	535,075
Total (237 plants):	**8,619,343**	**9,976,530**	**1,510,518**	**4,630,000**	**0**	**839,029**	**0**	**25,575,420**

Source:

MOE, July 1988, February 1989, May 1989, June 1989, August 1989, September 1989, December 1989 (2 reports) and August 1990.

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Table 2

Misa Monitoring: Estimated Operating Costs

MISA Sector	Sampling ($)	Flow Measurments ($)	ANALYTICAL TESTING			Reporting ($)	Miscellaneous ($)	Total ($)
			Characterization ($)	Routine Analysis ($)	Toxicity Testing ($)			
Petroleum	286,250	58,000	37,800	1,047,363	126,600	120,000	405,000	2,081,013
Organic Chemicals	1,077,700	107,100	784,700	5,375,300	326,400	375,300	0	8,046,500
Pulp & Paper	1,415,600	27,300	3,393,200	0	302,400	406,400	0	5,544,900
Iron & Steel	769,949	200,328	182,034	1,765,779	110,360	114,385	107,340	3,250,175
Metal Mining	9,400,000	2,200,000	0	0	0	2,500,000	0	14,100,000
Industrial Minierals	621,600	147,300	331,100	440,500	53,400	72,600	0	1,666,500
Electric Power	2,177,766	179,900	5,149,800	0	472,800	529,796	0	8,510,062
Inorganic Chemicals	1,112,500	23,000	357,700	2,353,500	208,800	50,600	0	4,106,100
Metal Casting	144,170	25,610	74,386	537,890	38,400	63,350	0	883,806
Total (237 plants):	**17,005,535**	**2,968,538**	**10,310,720**	**11,520,332**	**1,639,160**	**4,232,431**	**512,340**	**48,189,056**

Source:

MOE, July 1988, February 1989, May 1989, June 1989, August 1989, September 1989, December 1989 (2 reports) and August 1990.

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APPENDIX 2

MISA Actual Monitoring Cost Questionnaire

MISA

ACTUAL MONITORING COST QUESTIONNAIRE

The Monitoring Activities listed in this questionnaire are intended to correspond to those in the "Monitoring Cost Reports" that have been prepared for each sector.

The questionnaire consists of the following sections:

Section I: Identification

Section II: Consultants or Contractors Hired

Section III: One-Time Capital Expenses

Section IV: Recurring Operation Expenses

Section V: Effects on Operation

Please answer all questions. If this is not possible, please indicate the reasons according to the following:

1. If capital equipment, personnel or consultants are not required, please enter "NOT REQUIRED".

2. If the question is unclear and requires clarification, please enter "DO NOT UNDERSTAND".

3. If you have recorded a confidential answer and prefer that it not be released to the public, please enter beside the answer "CONFIDENTIAL".

4. Other, please specify.

Costs and expenses should include all relevant Provincial and Federal Taxes as well as contingencies.

Please call Rosemary Cercone at (416) 323-4400 if you have any questions or comments.

Section I: IDENTIFICATION

COMPANY NAME: _____

CORPORATE OWNER, IF DIFFERENT _____

PLANT NAME: _____

LOCATION: _____

MISA INDUSTRIAL SECTOR: _____ SIC#(s): _____

NAME OF PERSON WHO COMPLETED QUESTIONNAIRE: _____

TITLE: _____ PHONE NO: _____

FAX NO: _____

DATE QUESTIONNAIRE WAS COMPLETED: _____

NUMBER OF EMPLOYEES AT PLANT: _____

MAJOR PRODUCTS	TYPE	PLANT CAPACITY

MISA Sector _____
Plant Name _____

Section II: CONSULTANTS OR CONTRACTORS HIRED

1. Did your company hire a consultant/contractor to conduct various monitoring activities?

   Yes _____ No _____

Note: Was more than one consultant or contractor hired to complete MISA monitoring activities? Yes/No (Circle One). If yes, please photocopy and fill out page 3 and 4 for each consultant/contractor.

If yes, please indicate the consultant's/contractor's name and address.

Consultant's Name: _____

Address: _____

_____

_____

Total Contract Cost: _____

Please identify the types of monitoring activities that this Consultant/Contractor performed.

Monitoring Activity	Yes/No	Total Contract Cost ($000's)	Check here, if Contract Cost Information is Attached
Sampling			
Flow Measurement			
Reporting			
Chemical Analyses at Lab (excluding transportation)			
Toxicity Testing at Lab (excluding transportation)			
Transportation of Samples to Lab (see chart on next page)			
TOTAL CONTRACT COST			

Consultant or Contractor Costs - Other/Comments

_____

_____

_____

_____

_____

_____

MISA Sector _____
Plant Name _____

TRANSPORTATION OF SAMPLES TO COMMERCIAL LABORATORY
CONDUCTED BY COURIER/CONTRACTOR

Activity	Number of Tests Carried Out During Regulation Period	Method Used to Transport Samples to Lab (i.e., courier, bus, leased vehicle, existing vehicle)	Number of Shipments During Regulation Period	Total/Average Charge (please specify) ($000's)
Chemical Testing				
Toxicity Testing				
TOTAL				

☐ Check here, if a price list of individual test or other information is attached.

Comments:

_____
_____
_____
_____
_____
_____
_____

MISA Industrial Sector: _____

Plant Name: _____

Section III: ONE-TIME CAPITAL EXPENSES

If a device is not required please enter "NOT REQUIRED".

TABLE 1

CAPITAL COSTS - SAMPLING

MISA Sample Stream	Capital Costs ($000's)					
	Type of Sampler Installed	Delivered Price of Sampler	Installation	Building	Other	Comments
TOTAL						

MISA Industrial Sector: _____
Plant Name: _____

TABLE 2

CAPITAL COSTS - FLOW MEASUREMENT

MISA Sample Stream	Capital Costs ($000's)					
	Type of Device(s) Installed	Delivered Price of Flow Measurement Device	Installation/ Construction	Building*	Other	Comments
TOTAL						

* If not same building as for sampling device

TABLE 3

CAPITAL COSTS - CHEMICAL ANALYSES CONDUCTED IN-HOUSE

Equipment Purchased or Modifications to Current Lab	No.	Delivered Unit Cost/ Price	Installation	TOTAL CAPITAL COST ($000's)
TOTAL				

TABLE 4

CAPITAL COSTS - TOXICITY TESTING CONDUCTED IN-HOUSE

Equipment Purchased or Modifications to Current Lab	No.	Delivered Unit Cost/ Price	Installation	TOTAL CAPITAL COST ($000's)
TOTAL				

TABLE 5

CAPITAL COSTS - REPORTING

Equipment or Supplies Purchased	No.	Unit Cost/ Price	Installation	TOTAL CAPITAL COST ($000's)
Computers				
Hardware				
Software				
Other				
TOTAL				

CAPITAL COSTS - OTHER/COMMENTS

_____

_____

_____

_____

Section IV: OPERATING EXPENSES

TABLE 6

OPERATING COSTS - PERSONNEL TIME REQUIRED FOR SAMPLING ACTIVITIES

Activity	Employee Classification	Wage/Salary Rate (including Overhead & Benefits)	Total Person Hours For Year	TOTAL COST FOR YEAR ($000's)
Operation and Maintenance				
Sample Collection				
Other Labour Costs				
Sample Containers (and Travelling Blank and Spiked Samples)				
TOTAL				

TABLE 7

OPERATING COSTS - PERSONNEL TIME REQUIRED FOR FLOW MEASUREMENT

Activity	Employee Classification	Wage/Salary Rate (including Overhead & Benefits)	Total Person Hours For Year	TOTAL COST FOR YEAR ($000's)
Calibration				
Operation and Maintenance				
Other Labour Costs				
Sample Containers (and Travelling Blank and Spiked Samples)				
TOTAL				

MISA Sector _____
Plant Name _____

TABLE 8

OPERATING COSTS - REPORTING

Activity	Employee Classification	Wage/Salary Rate (including Overhead & Benefits)	Total Person Hours For Year	TOTAL COST FOR YEAR ($000's)
Data Entry				
Initial Report				
Monitoring Analyses Report				
Other				
TOTAL				

TABLE 9

OPERATING COST-IN-HOUSE ANALYTICAL TESTING

Activity	Employee Classification	Wage/Salary Rate (including Overhead & Benefits)	Total Person Hours For Year	TOTAL COST FOR YEAR ($000's)
Chemical Analyses				
Toxicity Testing				
Trout				
Daphnia Magna				
Characterization				
Open Characterization				
TOTAL				

MISA Sector _____
Plant Name _____

TABLE 10

OPERATING COSTS - TRAINING, SEMINARS

Activity	No.	No. of Persons Attended	Average Time Per Activity (Hours)	Cost Per Hour/Person	TOTAL COST ($000's)
Training Programs					
Seminars/ Conferences					
Other					
TOTAL					

Please list any additional expenses incurred when conducting training programs or seminars.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Section V: EFFECTS ON OPERATION

1. Was it necessary for your plant to hire additional staff in order to conduct the monitoring activities? Yes/No (Circle one).

   Permanent: Full-time No. _____ Part-time No. _____

Employee Classification	Wage/Salary Rate (including Overhead and Benefits)
_____	_____
_____	_____
_____	_____

   Temporary: Full-time No. _____ Part-time No. _____

Employee Classification	Wage/Salary Rate (including Overhead and Benefits)
_____	_____
_____	_____
_____	_____

2. Was it necessary for your plant to purchase/lease (circle one) a vehicle in order to conduct the monitoring activities?

   Yes _____ No _____

   If yes, what was the cost of using the vehicle for monitoring (please show calculations)?

3. During and as a result of the monitoring of your effluents, did you find out any of the following about the operation of your company?

   (a) Water use or pumping could be reduced. Yes/No (Circle One). If yes, please explain what, if anything, you did about it. Can you save money?

_____
_____
_____
_____
_____
_____
_____

(b) Raw material loss could be reduced. Yes/No (Circle One). If yes, please explain what, if anything, you did about it (e.g., type of material, location of loss, quantity of material, action taken, dollars saved, etc.).

(c) Product loss or spoilage could be reduced. Yes/No (Circle One). If yes, explain what, if anything, you did about it (e.g., action taken, money saved).

(d) Capital equipment acquired for monitoring can be used for other purposes. Yes/No (Circle One). If yes, please explain additional uses and cost saving (e.g., better flow control, research and development).

(e) Other consequences and comments.

APPENDIX 3

Reported Capital and Operating Costs By Monitoring Activity For Each Industrial Sector

REPORTED CAPITAL AND OPERATING COST BY MONITORING ACTIVITY BY SECTOR
($'000)

MISA SECTOR	SAMPLING			FLOW MEASUREMENT			ANALYTICAL TESTING		
	CAPITAL	OPERATING	TOTAL	CAPITAL	OPERATING	TOTAL	CAPITAL	OPERATING	TOTAL
PETROLEUM REFINING	399.5	367.9	**767.4**	994.2	18.2	**1,012.4**	339.9	605.3	**945.2**
ORGANIC CHEMICALS	2,329.9	1,538.8	**3,868.7**	1,075.9	137.7	**1,213.6**	1,839.2	1,022.1	**2,861.3**
PULP AND PAPER	274.8	549.4	**824.2**	1,974.6	68.8	**2,043.4**	125.9	351.2	**477.1**
IRON AND STEEL	116.6	121.6	**238.2**	311.5	104.9	**416.4**	257.0	149.1	**406.1**
METAL MINING	40.0	218.4	**258.4**	194.4	23.8	**218.2**	61.6	123.9	**185.6**
INDUSTRIAL MINERALS	22.1	34.9	**57.0**	77.0	7.5	**84.6**	0.0	24.1	**24.1**
ELECTRIC POWER GENERATION	5,128.1	1,882.9	**7,011.1**	4,239.6	432.2	**4,671.8**	3,744.1	2,381.4	**6,125.5**
INORGANIC CHEMICALS	760.3	383.0	**1,143.3**	702.4	64.0	**766.4**	244.6	686.7	**931.3**
METAL CASTING	0.8	1.1	**1.9**	4.4	1.0	**5.4**	0.0	0.0	**0.0**
TOTAL (117 plants):	**9,072.2**	**5,098.0**	**14,170.1**	**9,574.0**	**858.1**	**10,432.2**	**6,612.3**	**5,343.8**	**11,956.1**
% BY ACTIVITY	64.0%	36.0%	**100.0%**	91.8%	8.2%	100.0%	55.3%	44.7%	100.0%
% OF TOTAL			**26.8%**			**19.7%**			**22.6%**

SOURCE: MOEE, ACTUAL COST OF MONITORING SURVEY, 1991.

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REPORTED CAPITAL AND OPERATING COST BY MONITORING ACTIVITY BY SECTOR (cont'd)
($'000)

MISA SECTOR	REPORTING			TRAINING/ SEMINARS	IN-HOUSE TRANSPORTATION	CONSULTANTS	TOTAL
	CAPITAL	OPERATING	TOTAL				
PETROLEUM REFINING	102.2	444.4	546.5	124.0	0	676.7	4,072.2
ORGANIC CHEMICALS	128.5	1,172.2	1,300.7	426.6	52.8	2,912.6	12,636.3
PULP AND PAPER	95.1	263.1	358.2	81.2	0	1,378.1	5,162.2
IRON AND STEEL	14.2	142.9	157.1	32.8	0	456.0	1,706.6
METAL MINING	61.8	199.5	261.3	55.2	15.95	787.1	1,781.7
INDUSTRIAL MINERALS	6.1	23.0	29.1	5.3	0	184.7	384.8
ELECTRIC POWER GENERATION	443.1	1,524.6	1,967.7	249.9	34.0	2,410.9	22,470.9
INORGANIC CHEMICALS	88.3	296.3	384.6	51.2	6.3	1,403.2	4,686.3
METAL CASTING	0.0	2.4	2.4	18.0	0	16.0	43.6
TOTAL (117 plants):	939.2	4,068.4	5,007.7	1,044.3	109.1	10,225.2	52,944.6
% BY ACTIVITY	18.8%	81.2%	100.0%	100.0%	100.0%	100.0%	100.0%
% OF TOTAL			9.5%	2.0%	0.2%	19.3%	100.0%

APPENDIX 4

"t-Tests" to Determine Confidence Intervals

"t-Test" Analysis

The application of the two-tailed "t-test" assumes that estimated costs are a sample of the population and actual costs are the known population. Each plant within a sector is considered to be an observation, with the total number of observations equal to the number of plants in each sector for which both estimated and actual costs are available.

Assuming a normal distribution in both the sample and population, a sample t test statistic (t) was calculated for each sector, by dividing the difference in the mean of the actual costs and estimated costs by the standard deviation, such that,

$$t = \frac{Y_{actual} - Y_{estimated}}{\sqrt{(2s^2)/n}}$$

where,

t = t-test statistic

Y_{actual} = the mean of the actual costs for the industrial sector.

$Y_{estimated}$ = the mean of the estimated costs for the sector.

s^2 = common variance

n = number of plants per sector for which both estimated costs and actual costs are available.

Assuming a 5% level of significance, $\propto = .05$, a critical value (t^c) was obtained from the "Student's t Table" for 2(n-1) degrees of freedom for each sector.

If the value of the calculated "t test statistic" (t) is less than the critical "t value" (t^c), for a 5% level of significance, then ((one can be 95% confident that)) the estimates represent the actual costs.

APPENDIX 5

t Tests by Industrial Sector - Total

TOTAL FOR ALL 9 MISA SECTORS

PLANT NAMES	ESTIMATED TOTAL ($)	ESTIMATED TOTAL SQUARED ($)		ACTUAL TOTAL ($)	ACTUAL TOTAL SQUARED ($)
PETROLEUM REFINING	3,656,013	13,366,431,056,169		4,072,221	16,582,983,872,841
ORGANIC CHEMICALS	7,359,300	54,159,296,490,000		11,226,798	126,040,993,332,804
PULP AND PAPER	5,734,600	32,885,637,160,000		5,162,239	26,648,711,493,121
IRON AND STEEL	2,832,893	8,025,282,749,449		1,706,565	2,912,364,099,225
METAL MINING	6,195,158	38,379,982,644,964		1,781,720	3,174,526,158,400
INDUSTRIAL MINERALS	147,600	21,785,760,000		131,477	17,286,201,529
ELECTRIC POWER GENERATION	12,832,854	164,682,141,785,316		22,470,947	504,943,459,076,809
INORGANIC CHEMICALS	4,825,700	23,287,380,490,000		4,319,129	18,654,875,318,641
METAL CASTING	33,566	1,126,676,356		43638	1,904,275,044
SUM:	43,617,684	334,809,064,812,254		50,914,734	698,977,103,828,414
SUM ^ 2	1,902,502,357,523,856			2,592,310,138,290,756	
(SUM) ^ 2/9	211,389,150,835,984			288,034,459,810,084	
MEAN = SUM/9	4,846,409			5,657,193	
SUM(Y ^ 2) − (SUM Y) ^ 2/9	123,419,913,976,270.00			410,942,644,018,330.00	

WHERE,
df = 2(n−1)=16
n=9

COMMON VARIANCE	33,397,659,874,663
STANDARD DEVIATION = sqrt(2(common variance)/9)	2,724,280.12
CALCULATED "t−test" criterion = = (mean act − mean est)/standard deviation	0.2976

For 5% level of signifance:
the critical t value = 2.120, for df=16 and a two−tailed test.

Conclusion: MOEE is 95% confident that their estimates represent the actual MISA monitoring costs for all sectors.